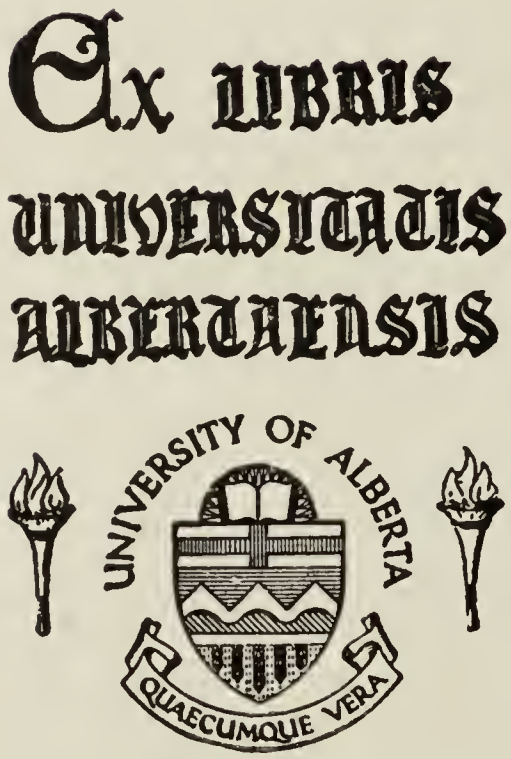

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FOOD HABITS AND HABITAT PREFERENCES OF *MICROTUS PENNSYLVANICUS* AND OTHER SMALL RODENTS

by

WM. H. SHARP

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "Food habits and habitat preferences of Microtus pennsylvanicus and other small rodents", submitted by Wm. H. Sharp in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

Trapping studies were undertaken during the summers of 1959, 1961, and 1963 in the vicinity of the Alberta Biological Station 20 miles west of Turner Valley, Alberta to survey the food habits and local distribution of mice.

Four species of mice were caught in numbers sufficient to indicate habitat preferences. The main requirement of Peromyscus maniculatus appeared to be sparse vegetation with a high proportion of forbs. Microtus pennsylvanicus and Zapus princeps were found mainly in deciduous forested areas, where Zapus appeared to prefer slightly denser and moister habitat than did Microtus. Clethrionomys gapperi was found in areas having a coniferous element of varying proportions.

The food habits of Microtus were studied by microscopic analysis of the stomach contents. Only two plant species, Vicia americana and Fragaria virginiana, were eaten in large quantities by the mice. Sixty-three of 73 mice ate four or fewer plant species. Availability of the major food plants appeared to control the proportions of these plants in the diet, although adults fed on more plant species than did immature animals.

Since the reproductive activity of the females remained fairly constant all summer and almost no

prenatal loss was observed, the low proportion of immature mice was attributed to mortality from birth to the weaning stage.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The distribution of an organism is governed by the interactions of the tolerance ranges of its biotypes with the environment. The complex relations between environmental factors and between those factors and the organism form a dynamic system which allows little or no independent influence by any single factor. The organism reacts to the whole environment as a dynamic unit.

Studies of any ecological factors must eventually relate the animal to its environment to be of much value in ecology. Some workers (Chew 1951, Rickard 1957, Getz 1960) have studied one or more factors on the level of a general survey, but few comprehensive studies have been carried out on the ecological relationships of mammals.

Authors have rarely related physiological data to the environment of the animal. Knowledge of the physiological requirements of the animal, and their availability in the environment must be correlated in any conclusive study. Much groundwork must be done before this can be accomplished.

Knowledge of the physiology of even domestic animals has barely reached the stage where metabolic functions can be explained with any certainty. Similar knowledge

of wild animals is almost totally lacking. Present knowledge of the physiology of terrestrial vertebrates is likely to have either no apparent distributional importance or to have a contribution so broad that it is of little assistance in the analysis of any specific distribution (Bartholemew 1958). Only recently has there been any trend in research toward this phase of study in wildlife (Smith 1959, Cowan 1957).

One aspect of animal ecology is nutrition. Proper study of this demands a detailed knowledge of the nutritional requirements of the animals in a given population, and the environmental supply of the needed biochemical constituents. Work of this sort would require a knowledge of the food habits of the animals.

This project was an attempt to determine the food habits of a small rodent by microscopical analysis of the stomach contents. Although very incomplete even in this respect, it can be used as an introduction for further work on food habits and nutrition.

METHODS

Several vegetation types were sampled during the summers of 1959, 1961, and 1963 by one of two methods. In 1959, a line of fifty museum special snap traps was set for one or two nights in each vegetation type. In the last two summers, a line of 100 traps spaced at 25 foot intervals was used for three consecutive nights. The trapping results were expressed as a coefficient indicating the numbers of mice of each species caught per 100 trapnights, one trapnight being one trap set for one night.

Where possible, large fairly uniform areas were chosen for trapping to minimize the effect of temporary immigration from adjacent habitats. Although the results obtained could not be converted to absolute population figures, they indicated relative population levels in the various habitats.

Identifications of animals caught were based on Rand (1948). Standard external measurements (Cockrum 1955) were made on all mice caught. The reproductive condition as indicated by length of testis in males and embryo and placental scar counts in the females was recorded.

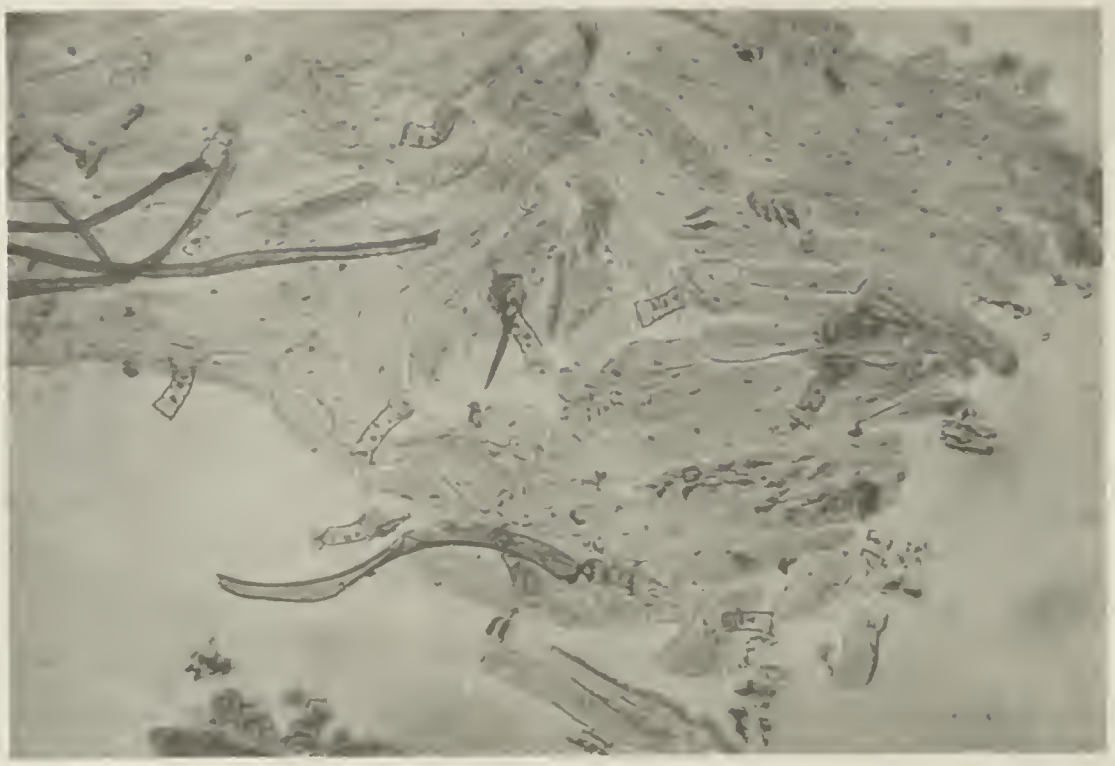
The animals were divided into two age categories. The adult category included all sexually mature animals

and individuals whose age was questionable. The immature category included smaller animals with lighter grey coat color and small undeveloped reproductive organs.

The stomach contents of the mice were preserved in Formalin-aceto-alcohol (FAA Johansen 1940) for future identification of the plant materials.

A species list was made of the plants in each trapping area and a notation of abundance was made according to the scale of Tansley and Adamson (in Phillips 1959, see Appendix A). Cover was estimated visually at the time of analysis. Most of the vegetation analyses were carried out during the late summer when the plants, especially grasses, were in bloom and identifiable. The manuals used in plant identification were Campbell et al (1956), Clarke et al (1950), Hitchcock (1950) and Moss (1959). Where a conflict arose on names, the nomenclature used by Moss was followed.

The eight main categories of abundance were given numerical values from one to eight in order of increasing abundance (see Appendix A) to obtain a mean value of occurrence and distribution of important plant species in all the study areas. This figure of abundance was compared with the number of mice eating the species to show the plant species preferred by the mouse.



A

B

Figure 1. Epidermal Tissues of Leaf of Achillea millefolium from Reference Slide (A), and from Stomach Sample (B).

Herbarium specimens were collected and identified. Portions of the flower, leaf and stem of each specimen were preserved in FAA for preparation of a series of reference microscope slides of epidermal tissue.

These slides were prepared by macerating the portions of plant tissues in Jeffrey's solution (Johansen 1940) until the epidermal tissues could be stripped off the underlying layers. Usually maceration was allowed to proceed for about 24 hours at room temperature, but some specimens required longer treatment. The tissue was stained in Delafield's hematoxylin and mounted on microscope slides in Euparal mounting medium. The procedure generally follows that of Dusi (1949), but with a different stain and mounting medium.

A partial key to the epidermal tissues of the plant species involved was constructed for each area, using the prepared slides. Reference photographs were also made for more detailed comparison (See appendix D).

Material in the mouse stomachs was identified by use of the key and by comparison of the epidermal tissues in the stomach contents with the reference slides (see Fig. 1.). Estimates were made of the proportions of plant species eaten by tabulating the frequency of occurrence of each species in the observed stomach content samples.

Kendeigh (1961) pointed out several disadvantages

to this system of food habit analysis. Although stomach contents show what the animal has actually eaten, this method can show only the components of one meal or part of one meal. It does not indicate how the animals obtained their food, although such considerations are more important with predators and scavengers than with herbivores. No indication of the volume of food eaten in a specified period of time is given by this method. The method by itself allows no quantitative approach to the food habit problem.

The main advantage of such an analysis is that the animals are not subjected to artificial conditions. In field work of this sort all types of food that are normally available to the animals are present in their natural proportions, whereas food of confined animals would probably not simulate the environmental situation in either quality or quantity. Since ecology is the study of the relationships of the animals to their environment and not the study of artificial conditions, I feel that there is less chance for error in the above method.

This study by itself is incomplete since it gives no information concerning the nutritional values of the food eaten nor any indication of seasonal or geographical variations in the nutritional value of any one plant species. For a proper assessment of the value of the

diet the biochemical composition of the food and the nutritional requirements of the animals being studied including seasonal and spatial variations, must be known. Biologists have only recently begun to explore this area of population dynamics.

THE AREA

This project was conducted in the vicinity of the Alberta Biological Station in the Rocky Mountains Forest Reserve, 20 miles west of Turner Valley, Alberta. The region concerned is generally called the foothills belt of the Rocky Mountains.

The topography of the area is hilly to mountainous, varying in altitude from about 4,000 feet in the river valley to nearly 10,000 feet on nearby peaks. The rough terrain is cut in several places by the Sheep River or its tributaries.

Very little organic matter is present in the soil, due to insufficient production or to removal by fire. The thin layer of glacial till is underlain by bedrock which forms numerous outcrops throughout the area. Only in poorly drained boggy areas and in small unburned patches of spruce has there been any accumulation of organic matter.

The vegetation is predominantly coniferous forest interspersed with deciduous forest and grassland. The general pattern of distribution consists of coniferous forest on the more mesic and cooler sites, as the north-facing slopes, deciduous forest on driest locations, and herbaceous vegetation on the most exposed locations. The whole area lies within the boreal-cordilleran transition

zone of vegetation.

Over much of the region lodgepole pine (Pinus contorta) forms dense, homogeneous stands, probably a disclimax caused by fire (Cormack 1953). Undergrowth varies from almost nothing under dense pine stands to a sparse cover of shrubby and herbaceous vegetation in the more open stands. The main associated species include Calamagrostis montanensis, Elymus innovatus, and Arctostaphylos uva-ursi (see Appendix B for common names of plant species).

Aspen poplar (Populus tremuloides) is dominant over large areas on moist south-facing slopes and at lower elevations in the river valley. Considerably more undergrowth occurs even in dense stands of this species than in the pine stands. Associated species include Agropyron trachycaulum, Aster ciliolatus, Epilobium angustifolium, Fragaria virginiana, Galium boreale, Lathyrus ochroleucus Rosa woodsii, Rubus strigosus, Shepherdia canadensis, Thalictrum venulosum, and Vicia americana. As in the pine associations the abundance and variety of herbaceous vegetation increases with decrease in the density of the dominant forms.

Many areas contain a mixture of varying proportions of the types mentioned above. Other trees of lesser importance include balsam poplar, (Populus balsamifera), Douglas fir (Pseudotsuga menziesii), and white spruce

(Picea glauca) at the lower altitudes, and alpine fir (Abies lasiocarpa), limber pine (Pinus flexilis), and larch (Larix sp.) at the higher altitudes.

Of the above species, only white spruce forms even small pure stands within the region studied. Stands of this species are located in very moist habitat or in isolated locations, indicating they are probably remnants of a formerly extensive climax association destroyed by fire.

Dry, exposed locations are covered by herbaceous vegetation, mainly graminoids. Grasses are dominant on the flats or terraces and more stable slopes. Although this area is included in the Festuca scabrella grassland zone (Moss 1955) very little of this species is actually present. Agropyron sp. and Stipa richardsonii are dominant on the more mesic sites, and Danthonia parryi is locally dominant on the driest sites.

The proportion of forbs increases with decreasing stability of the soil, usually due to increased slope on the hillsides. A high proportion of forbs and shrubs occurs on talus slopes, where few grasses are found.

Poorly drained areas at all altitudes support a bog vegetation. Mosses, sedges and ericaceous plants dominate the majority of such locations, while bog birch (Betula sp.) and willow (Salix sp.) form dense thickets

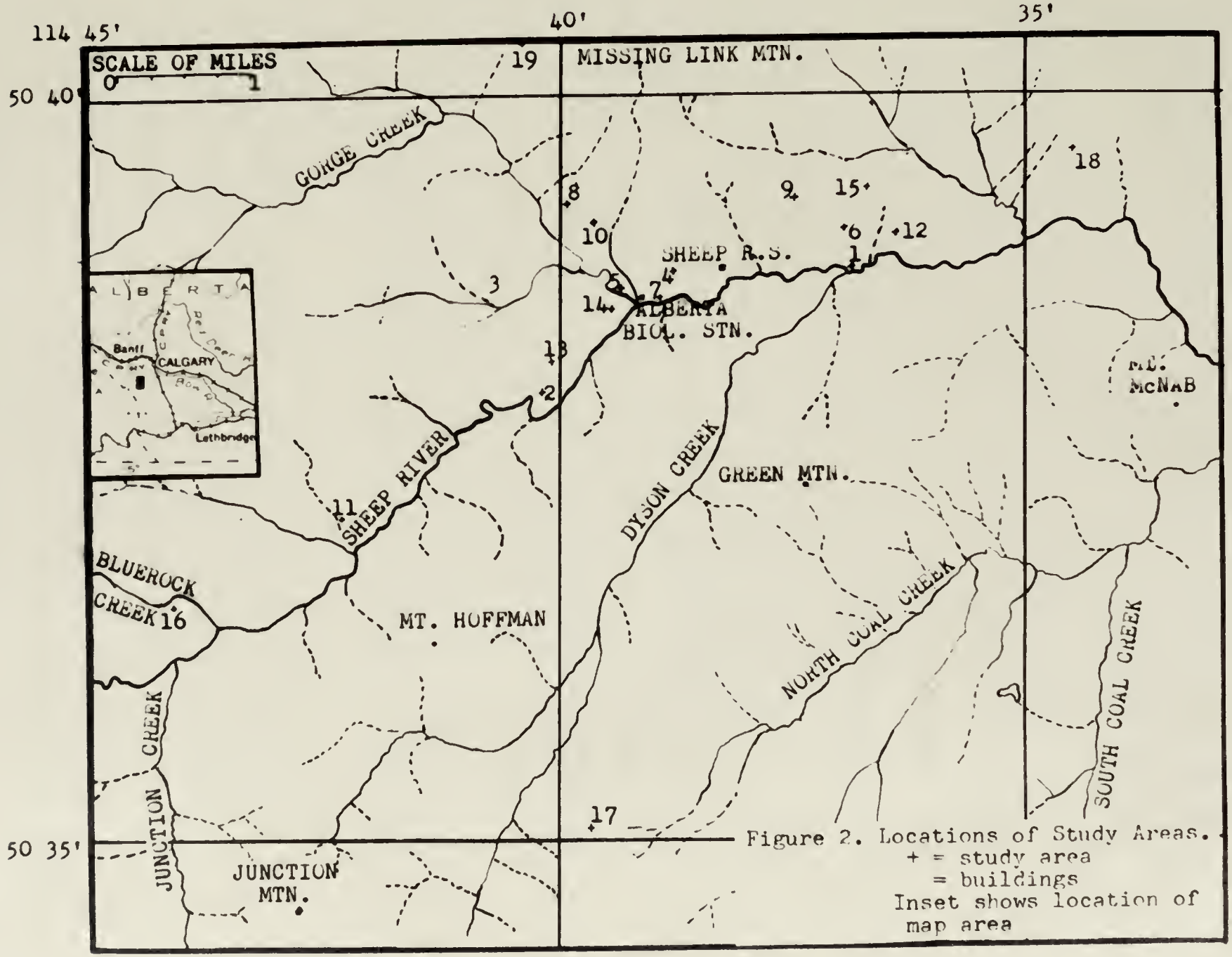


Figure 2. Locations of Study Areas.
+ = study area
= buildings
Inset shows location of map area

on others. In most of these areas standing water occurs between the humps or is present a few inches below the surface.

DESCRIPTION OF STUDY AREAS

The method of description follows that of Getz (1960). The general type of vegetation is indicated at the head of each area description. The field stratum included all herbaceous vegetation and woody plants growing at the same level. Size was estimated, where possible, from aerial photographs. See map (Fig. 2) for locations of the study areas.

Area 1. (Fig. 3) Grassland. Size 10 acres.

Tree and shrub strata absent; field stratum very well developed (Agropyron sp., Bromus sp., Festuca sp., Achillea millefolium, Artemisia sp., Fragaria virgininana, and Potentilla gracilis); cover varying from 0 to 50 per cent; substrate gravelly with very little organic matter.

Area 2. Grassland. Size 5 acres.

Tree and shrub strata absent; field stratum well developed (Phleum pratense, Deschampsia caespitosa, Trifolium hybridum); cover about 75 per cent, consisting of much dead vegetation, mainly bunchgrasses; substrate with small amount of organic matter.

Area 3. Grassland. Size 10 acres.

Tree and shrub strata absent; field stratum fairly well developed, grazed (Poa pratensis, D. caespitosa, Agropyron sp., P. gracilis, A. millefolium, Galium

boreale, Taraxacum officinale, and Aster sp.); cover less than 25 per cent; substrate with very little organic matter.

Area 4. Grassland, Size about 20 acres.

Tree and shrub strata present on the fringes; field stratum well developed (Festuca scabrella, Epilobium angustifolium, P. gracilis, Anemone multifida); cover varying from about 25 to 75 percent; thin organic layer on surface.

Area 5. Grassland. Size 2 acres.

Tree and shrub strata almost absent (Populus tremuloides, Salix sp.); field stratum present but sparse (Stipa richardsonii, Danthonia intermedia, Trisetum cernuum, F. scabrella, V. americana, A. millefolium, Symphoricarpos occidentalis, and Aster sp.); cover about 25 percent; substrate with very little organic matter.

Area 6. Open aspen. Size 9 acres.

Tree stratum partially developed, canopy open (Populus tremuloides, Salix sp.); field stratum very well developed (E. innovatus, B. ciliatus, Poa sp., E. angustifolium, F. virginiana, L. ochroleucus, V. americana, and T. officinale); cover approximately 50 percent; substrate with thin layer of organic matter.

Area 7. Aspen. Size 11 acres.

Tree stratum present, canopy open (Populus tremuloides);

shrub stratum present, very poorly developed (Shepherdia canadensis, Rosa sp.); field stratum present but poorly developed (E. innovatus, Agropyron sp., F. virginiana, V. americana); cover less than 25 per cent; substrate mainly inorganic.

Area 8. Aspen. Size 7 acres.

Tree stratum present but poorly developed, canopy partially open (P. tremuloides); shrub stratum absent; field stratum fairly well developed (E. innovatus, A. millefolium, F. virginiana, and P. fruiticosa); cover 25 to 50 per cent; substrate with very little organic matter.

Area 9. Fairly dense aspen. Size 20 acres.

Tree stratum well developed, canopy nearly closed (P. tremuloides); shrub stratum almost absent (Salix sp.); field stratum variable but usually well developed (E. angustifolium, Heracleum lanatum, Viola rugulosa, Aster sp., S. columbiana, C. montanensis); cover usually less than 50 per cent; substrate with some organic matter.

Area 10. (Fig.4). Aspen. Size 15 acres.

Tree stratum sparse, canopy closed (P. tremuloides); shrub stratum absent; field stratum variable, usually well developed (E. innovatus, T. cernuum, E. angustifolium, F. virginiana, T. officinale, and H. lanatum); cover over 75 per cent; substrate with a thin layer of leaves and grass.

Figure 3. Area 1. Open Grassland

Figure 4. Area 10. Aspen

Area 11. Aspen.

Tree stratum well developed, canopy nearly closed (P. tremuloides); shrub stratum almost absent (Rosa sp.); field stratum poorly developed, grazed (E. innovatus, T. officinale, Vaccinium sp.); no cover; substrate with very little organic matter; Trapping done along a rock outcrop in this area.

Area 12. Aspen. Size 10 acres.

Tree stratum well developed, canopy open (P. tremuloides); shrub stratum absent; field stratum poorly developed, grazed (F. virginiana, E. angustifolium, L. ochroleucus, V. americana); cover about 25 per cent; substrate with small amount of organic matter.

Area 13. Aspen. Size about 5 acres.

Tree stratum fairly well developed, many trees cut down by beaver, canopy open (P. tremuloides, P. glauca); shrub stratum absent; field stratum not very well developed, grazed (Mitella nuda, F. virginiana, Calamagrostis sp.); cover about 25 per cent; substrate with very little organic matter.

Area 14. Aspen-pine. Size over 20 acres.

Tree stratum fairly well developed, canopy open (P. tremuloides, Pinus contorta); shrub stratum present (S. canadensis, Spirea lucida); field stratum poorly developed, grazed (E. innovatus, F. virginiana); cover less than 25 percent; substrate with little organic matter.

Area 15. (Fig. 5). Pine-aspen. Size over 20 acres.

Tree stratum well developed, canopy mostly open (P. contorta, P. tremuloides); shrub stratum present (S. canadensis); field stratum present, grazed (C. montanensis, E. angustifolium, E. innovatus, L. ochroleucus, Aster sp.); cover less than 25 per cent; substrate with many lichens, very little organic matter.

Area 16. Spruce-pine. Size over 20 acres.

Tree stratum well developed, canopy open (P. glauca, P. contorta); shrub stratum nearly absent; field stratum fairly well developed (E. innovatus, F. virginiana, A. uva-ursi, Trifolium hybridum); cover less than 25 per cent; substrate with some organic matter.

Area 17. Rocky outcrop.

Tree stratum very poorly developed, old burn (P. contorta); shrub stratum absent; field stratum sparse (P. fruiticosa, A. multifida, Poa sp., Astragalus sp., A. trachycaulum); no cover; substrate with no organic matter.

Area 18. Talus slope. (Fig. 6)

Tree stratum absent; shrub stratum present (Eleagnus argentea, Prunus virginiana, S. occidentalis); field stratum very sparse; no cover; substrate of loose rock.

Area 19. Bog. Size 10 acres.

Tree stratum absent; shrub stratum present (Betula sp.); field stratum poorly developed (Carex sp., Juncus balticus V. americana, Aster sp., E. angustifolium); substrate of mosses and organic matter.

Figure 5. Area 15. Pine-aspen

Figure 6. Area 18. Talus slope

RESULTS

Table 1 gives the numbers of rodents captured and the coefficient of animals caught per 100 trapnights on each area.

The species caught in order of abundance were the deermouse (Peromyscus maniculatus), short-tailed meadow vole (Microtus pennsylvanicus), Rocky Mountain jumping mouse (Zapus princeps), red-backed vole (Clethrionomys gapperi), yellow pine chipmunk (Eutamias amoenus), least chipmunk (E. minimus), long-tailed meadow vole (M. longicaudus), phenacomys vole (Phenacomys intermedius), pocket gopher (Thomomys talpoides), flying squirrel (Glaucomys sabrinus), columbian ground squirrel (Citellus columbianus), and the thirteen-lined ground squirrel (C. tridecemlineatus). Only the first four species were caught in sufficient numbers to allow reliable indications of habitat preferences.

Because of the types of food eaten by the various species I was able to identify food materials from the stomachs of Microtus only. No provision was made for identification of seed and root material, which appeared to form the major food items of Peromyscus, Zapus, and Clethrionomys. The discussion of diet is therefore limited to Microtus pennsylvanicus.

Although no statistical tests were carried out to show this trend, the data (see table 2) indicated that each species was more common in one habitat type than in

Table 1. Trapping results

Area	Date Trapped	Number of Trap Nights	Number of each species caught: Peromyscus maniculatus Total	Number 100 TN.	Microtus pennsylvanicus Total	Number 100 TN.	Zapus princeps Total	Number 100 TN.	Clethrionomys gapperi Total	Number 100 TN.
1	2-4 June '61	300	16	5.3	4	1.3				
2	9-11 July '63	300	2	1.6	10	3.3				
3	8 July '59	50	2	4						
4	13-15 July '63	300	13	4.3	5	1.6				
5	7-8 June '59	100	4	4	1	1			3	3
	17 Aug '59	50	1	2	2	4				
6	1-3 Aug. '59	150			10	6.7			3	2
	22-24 May '61	300	1	.3	1	.3				
	2-4 Aug. '63	300			7	2.3			7	2.3

Table 1. continued.

Area	Date Trapped	Number of Trap Nights	Number of each species caught: Peromyscus maniculatus Total Number	100 TN.	Microtus pennsylvanicus Total Number	100 TN.	Zapus princeps Total Number	100 TN.	Clethrionomys gapperi Total Number	100 TN.
7	16-19 May '61	300	25	8.3						
8	2-4 July '61	300	18	6	4	1.3	7	2.3		
9	26-28 May '61	300	7	2.3			3	1		
10	23-25 June '61	300	6	2	5	1.6	13	4.3		
	18-20 July '63	300	4	1.3	23	7.6	3	1		
	11-13 Aug. '63	300	7	2.3	17	5.6	13	4.3		
11	2-4 June '61	300	25	8.3	1	0.3			1	0.3
12	14-16 May '61	300	5	1.6	1	0.3				
13	6-8 June '61	300	5	1.6	5	1.6			1	0.3

Table 1. continued

Area	Date Trapped	Number of Trap Nights	Number of each species caught: Peromyscus maniculatus Total	Number 100 TN.	Microtus pennsylvanicus Total	Number 100 TN.	Zapus princeps Total	Number 100 TN.	Clethrionomys gapperi Total	Number 100 TN.
14	11-13 July '61	300	30	10			1	0.3	2	0.6
15	16-18 May '61	300	2	0.6					1	0.3
16	21-23 June '61	300	4	1.3	3	1			8	2.6
17	4-6 July '61	300	14	4.6	1	0.3			1	0.3
18	9-13 May '61	300	17	5.6	1	0.3				
19	26-28 June '61	300	1	0.3	1	0.3			1	0.3

Table 2. Trapping results from six main habitat types.

Mouse	Grass land	Deciduous forest	Mixed forest	Coniferous forest	Rock Talus	Bog
Peromyscus maniculatus	38 *(3.5)	73 (2.5)	37 (4.1)	4 (1.3)	56 (6.2)	1 (0.3)
Microtus pennsylvanicus	22 (2)	68 (2.4)	5 (0.6)	3 (1)	3 (0.3)	1 (0.3)
Zapus princeps	3 (0.3)	49 (1.7)	1 (0.1)			
Clethrionomys gapperi			4 (0.4)	8 (2.6)	2 (0.2)	1 (0.3)

*Figures in brackets indicate number of mice per 100 trapnights.

Table 3. Populations of Microtus pennsylvanicus, amount of cover, and abundance of the main food plants.

Area	Voles per 100 T.N.	Cover %	Vicia	Taraxacum	Achillea	Fragaria
10	5	75	vc	vc	c	vc
2	3.3	75	f	r	o	f
6	2.4	50	va	vc	c	va
5	2.0	25	o	r	c	
4	1.6	25-75	o		f	c
13	1.6	25	o	f	c	vc
1	1.3	0-50	o		c	vc
8	1.3	25-50	o	o	vc	va
16	1.0	25	o	f	f	vc
11	0.3	0	f	vc	c	c
12	0.3	25	c	c	f	a
17	0.3	0		vr		
18	0.3	0			r	
19	0.3	0	r		c	f

Table 4. Plant species eaten by 73 Microtus pennsylvanicus

Plant species	Index of** Abundance	Frequency of occurrence in 73 stomachs								
		1	2	3	4	5	7	15-20	21-40	41-60	61+
Muhlenbergia sp.				x							
Collomia linearis		x									
Danthonia parryi	0 -0.49	x									
Rinanthus crista-galli		x									
Rosa sp.		x									
Bromus inermis					x						
Festuca idahoensis				x							
Astragalus sp.	0.5-0.99	x									
Gallairdia aristata		x									
Juncus balticus		x									
Rumex sp.		x									
Ziza aptera		x									
Mertensia paniculata						x					
Anemone multifida			x								
Oxytropis campestris	1.0-1.49		x								
Allium cernuum		x									
Solidago gigantea		x									
Bromus ciliatus				x							
Agropyron subsecundum	1.5-1.99	x									
Deschampsia caespitosa		x									
Stipa columbiana	2.0-2.49	x									
Thalictrum sp.		x									
Agropyron trachycaulum	2.5-2.99	x									
Lathyrus ochroleucus							x				
Phleum pratense	3.0-3.49		x								
Carex sp.		x									
Galium boreale		x									
Vicia americana											x
Taraxacum officinale	3.5-3.99								x		
Poa sp.							x				
Epilobium angustifolium					x						
Fragaria virginiana									x		
Achillea millefolium	4.0-4.49							x			
Aster sp.						x					

** See appendix A for interpretation of the index of abundance.

Figure 7. Number of plant species eaten by individual voles (Microtus pennsylvanicus)

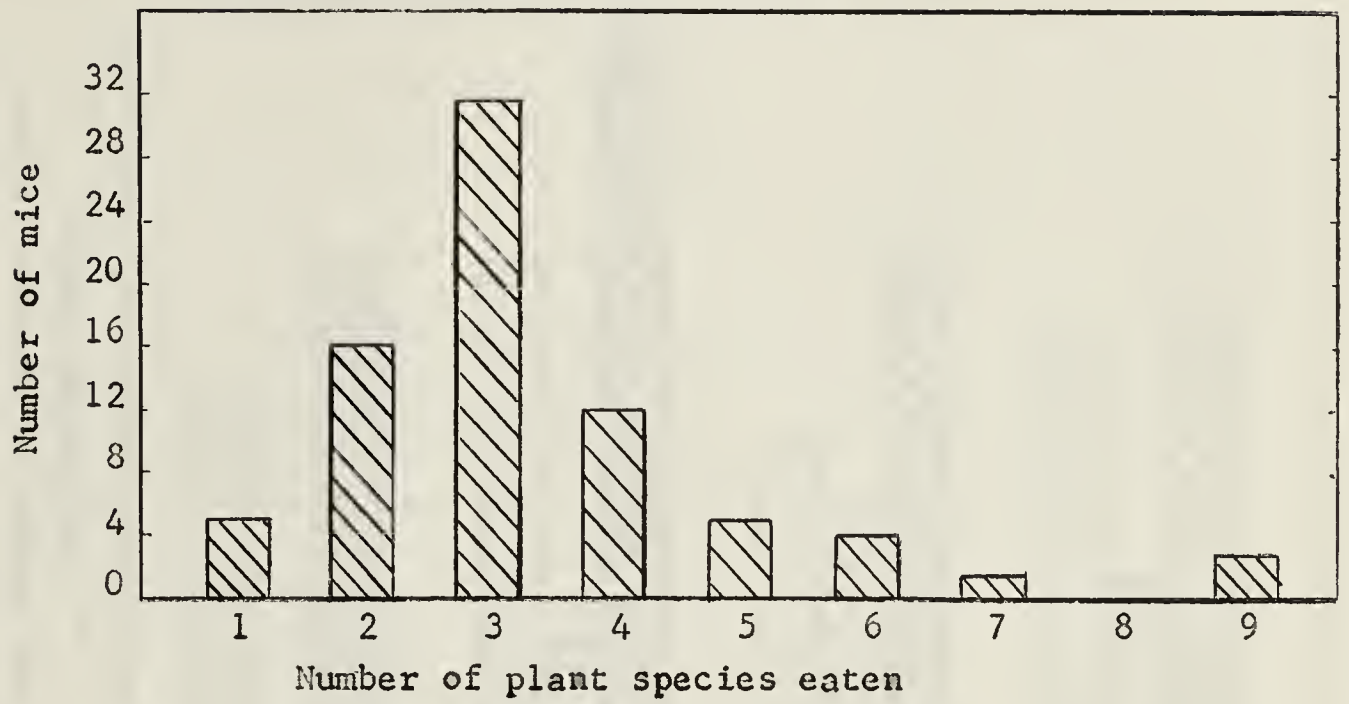


Figure 8. Numbers of adult and immature Microtus pennsylvanicus in each month.

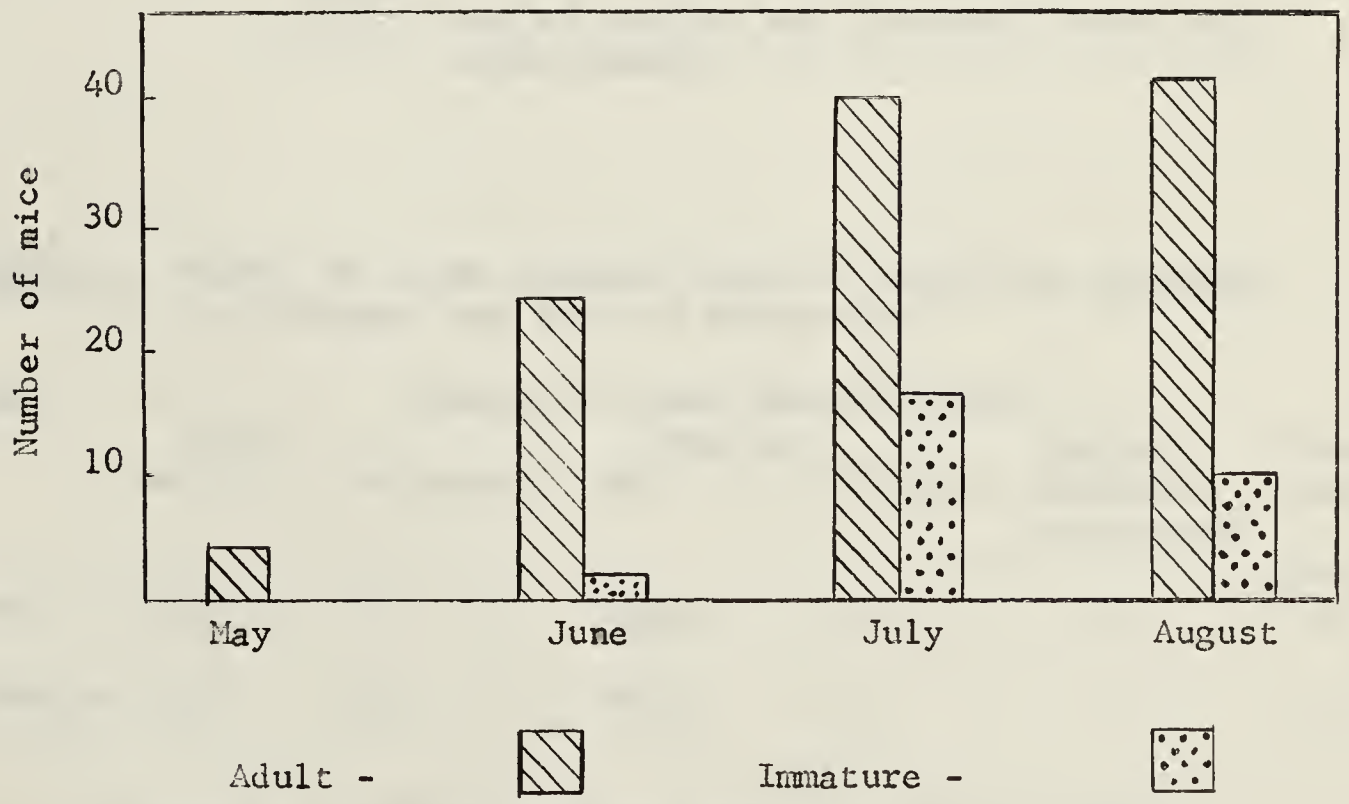
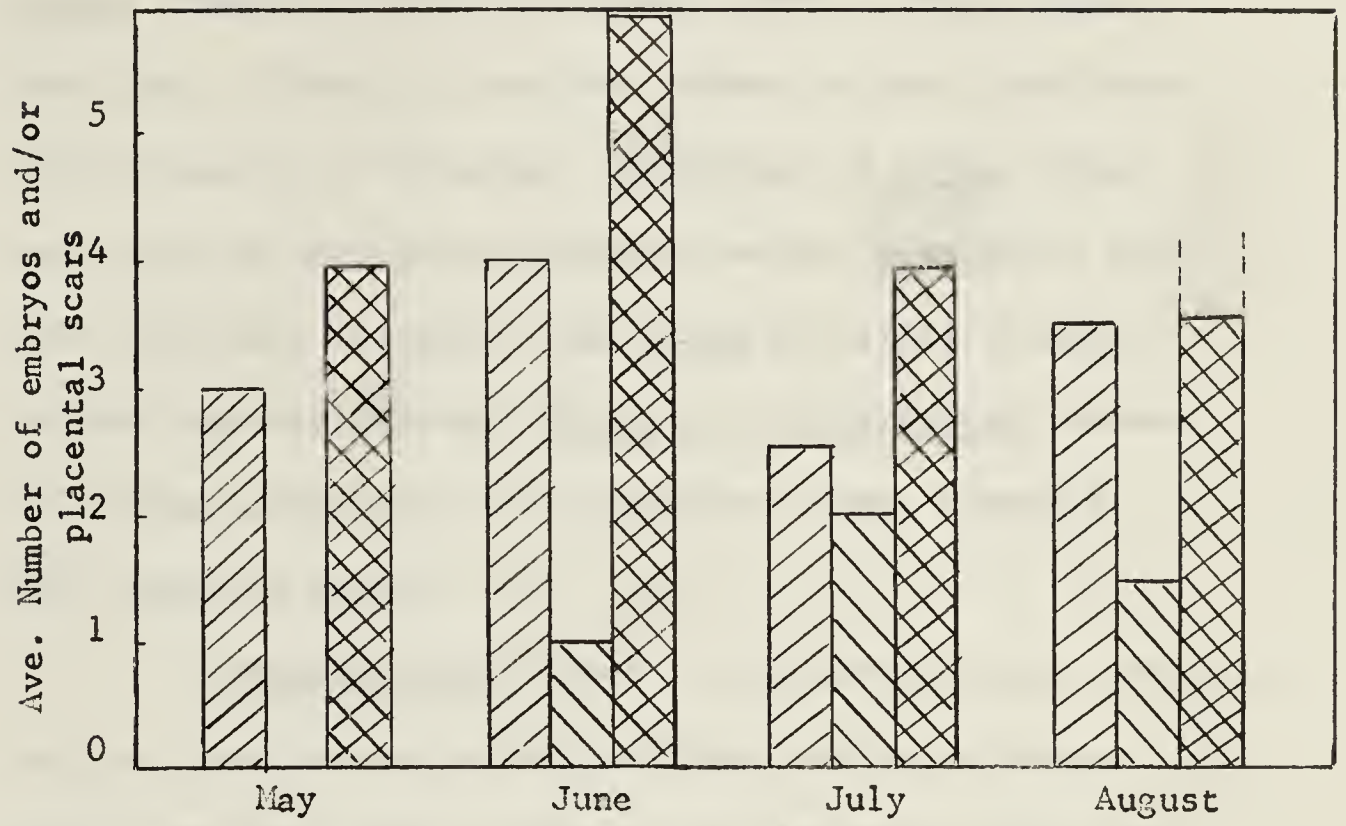


Figure 9. Reproductive activity of adult female voles (Microtus pennsylvanicus) in each summer month.



Legend: ▨ = number of embryos per adult female

▧ = number of placental scars per adult female

▩ = sum of embryos and placental scars per adult female.

Table 5. Number of plant species eaten by individual Microtus in different age and sex categories.

Age	Number of plant species eaten					
	Males		Females		Species common to both sexes	Total number of plant species
	No.	Av./mouse	No.	Av./mouse		
Adult	16(27)*	3	16(26)	3.1	12	20
Immature	6(7)	2.6	14(8)	3.6	5	15

*Figures in brackets indicate number of mice in that category.

the others, as was also noted by Johnson (1926). Peromyscus showed the least tendency toward a single habitat type, although it was less common in pure coniferous forest than in other areas. Microtus and Zapus showed very similar habitat preferences, mainly open aspen forest. The data indicated that Zapus preferred slightly moister habitat than did Microtus. Clethrionomys showed a distinct preference for coniferous forest elements, both pine and spruce.

Peromyscus was found in all habitat types trapped, but was most common in rock outcrops and talus slopes. It appeared to prefer sparse vegetation with a high incidence of plant species, especially forbs (e.g. Areas 7, 11 and 14).

Very little plant material was identifiable in the stomachs of this species. The diet of Peromyscus appeared to be mainly seeds, which were found to be very difficult to identify, hence, no attempt was made in this study to include stomach analyses of Peromyscus maniculatus.

Zapus princeps was caught only in grassland and aspen forest (see Table 2). It reached its highest populations in areas of large, widely-spaced aspen with an almost complete canopy (Area 10).

Stomach samples from this species indicated that Zapus ate seeds and fruits, although some individuals

ate green material. One stomach was almost completely filled by Vicia leaves. The diet also included insect material. Very little other identifiable material was present in the stomachs of this species.

Clethrionomys gapperi was never caught in large numbers in any of the habitats trapped. It reached its greatest density in an area of open spruce and pine along an old sawmill road (Area 16), where it was the most common species. Table 2 shows its preferred habitat as coniferous forest.

Stomach samples collected contained much unidentifiable root material, some ascomycete and insect material and a fairly large proportion of the leaves of Vicia. Almost no grass material was present.

Microtus pennsylvanicus reached its highest populations in areas where aspen formed an open canopy (Areas 6 and 10). The vegetation of these areas contained a high proportion of broad-leaved plants and was usually dense enough to form an almost complete canopy. This mouse was more common in grassland and deciduous forest than in other habitats. (Table 2)

Table 3 indicates that cover was of primary importance in determining population levels of Microtus. The effect of the abundance of the food plants was evident only in those areas of similar cover value.

Of 73 mice, 63 ate four or fewer plant species, and over one-half of these ate three or fewer species. Only four species of plants, none of them grasses, were eaten by ten per cent or more of the mice.

Vicia americana and Fragaria virginiana were eaten by 87 per cent and 53 per cent respectively of the total number of animals (see Table 4). Fragaria was consumed in much smaller quantities than was Vicia. The leaves were eaten in far greater quantities than were other portions of the plants.

Grasses comprised over 25 per cent of the stomach contents in only five cases. Four grasses were included in this group: Agropyron trachycaulum, Bromus inermis, Phleum pratense, and Poa sp. In only two cases did the proportion of grasses reach 50 per cent.

Adult voles and immature female voles fed on approximately the same number of plants, while immature males ate far fewer plant species (Table 5). All plant species eaten by immature voles were eaten by adult voles.

Other food materials found were insects, which were eaten by nine voles, and fungal spores, eaten by eight voles. Large starch-filled cells were also found in three voles. These items formed a very small proportion of the stomach contents in which they were found.

The sum of the number of embryos per adult female in each month and the number of placental scars per adult female for the subsequent month shows that reproduction was highest during June. Immature voles reached the highest proportion of the total number of voles caught in July.

The proportion of immature animals taken showed considerable variation between study areas. Those areas supporting the highest populations of mice also showed the highest proportion of immature mice. The deciduous forest and grassland habitats supported relative populations of 2.4 and 2 voles respectively per 100 trapnights (see Table 2). Thirty-two per cent of the voles from the deciduous forest and five per cent of the voles caught in the grassland were immature. All other habitats supported one vole or less per 100 trapnights and yielded no immature voles.

DISCUSSION

Peromyscus maniculatus

Peromyscus preferred sparse vegetation of mixed composition, although it was found in other habitats. Williams (1955) found it in similar habitat where the vegetation was representative of fairly early successional stages. These ecological requirements of Peromyscus appear to be provided over a wide geographical range.

Most authors agree that fruiting bodies constitute the major food item of this mouse Linduska (1955) suggested that food habits varied with availability. Rickard (1957) thought that due to variety in its diet no particular food item is important. Getz (1960) found that one species, *P. leucopus*, was scarce at time of study in areas having an unstable food supply. The populations of Peromyscus would tend to fluctuate irregularly, depending on the supply of fruiting bodies produced by the plants in its environment.

Zapus princeps

This mouse appeared to prefer open deciduous forest and some grassland. It was uncommon in forest containing coniferous elements.

In 1959, the first individuals of this species were captured on June 8, while in 1961, the first ones were caught on May 27 (see Table 1). As this species is at

least a partial hibernator (Rand, 1948), the records may be some indication of the time of emergence of this animal. The animals caught on the above dates were all males. Females were not caught until June 23 and 24, when seven of ten specimens trapped were females. This species may be similar to Z. hudsonius in which Quimby (1951) found that males emerged about two weeks earlier than did the females.

Quimby found that Z. hudsonius prefers starchy seeds and fleshy fruits to other plant materials. Stomach samples from Z. princeps indicated similar food habits, although some ate more green material. As the two species are closely related, one would expect a similarity in food habits.

Clethrionomys gapperi

Clethrionomys appeared to prefer coniferous forest or mixed forest with a coniferous element. Williams (1955) found it most typical of areas where trees formed a continuous canopy and logs and stumps provided cover. These features were never generally abundant where Clethrionomys was found in this area, which supported a low population.

Rickard (1957) considers its distribution to be related to moisture conditions, since he and Butsch (in Rickard) found it most common in moist places with heavy ground cover. In this study only two of fifteen individuals were caught in low moist locations. Cover was

very sparse in all areas where it was taken, although other authors (Rickard 1957, Williams 1955) found it most common in areas with plentiful ground cover. Manville (1949) includes a considerable variety of food materials in the diet of Clethrionomys, such as all parts of grasses, fruits, and the bark of trees and shrubs. Rickard states that it feeds largely on green vegetation. Stomach samples from this study contained much of the above plus root, fungus and insect material.

Microtus pennsylvanicus

This vole was found in all the habitat types trapped (Table 2) but was most common in grassland and deciduous forest. It reached its highest populations in one area of open aspen forest (Area 10) and one of open grassland (Area 2).

The general ecological requirements of this species appear to be moist, dense vegetation, predominantly graminoid, with a high cover value. Dense vegetation appears to be necessary for the construction of runways. Getz (1960) found this species common in dense vegetation of a graminoid nature, but absent from less dense adjacent areas.

Although cover appeared to be a primary factor in governing the ecological distribution of this vole (Table 3), some effect of the availability of the major food plants on vole distribution was noted. Area 2 had an amount of cover similar to that on area 10, but had a lower abundance of the food plants. It also had a lower

population of voles. In most cases the effect of food plant distribution, if any, was masked by variations in cover.

The general correlation in Table 3 between the presence and abundance of the plant species listed and vole populations may be due more to the affinity of both the plants and the vole for the same biotic association, rather than a direct effect of the plants on the voles.

Microtus ate an average of three plant species each, or less than ten per cent of the total number of plants present. Hawbecker (1947) found a similar situation with the Nelson antelope ground squirrel. Thus the total amount of vegetation may not be an indication of the amount of food available to the animal.

Both adults and immature voles ate about three plant species per animal (see Table 5). Adults tended to show more individual variation and hence a greater range of plant species for the whole group. The observed narrower range of food plants for immature male voles may have been due to the small sample size and not to a group characteristic.

Some variation in food habits was observed in different trapping areas, both in the number of plants eaten by individuals, and in the range of plant species

eaten. The proportions of the food plants in the environment apparently influenced their proportions in the diet of Microtus.

There was no significant seasonal variation in the food habits of this vole during the period of this study, which extended from late spring to early autumn.

Contrary to opinions expressed in the literature (Getz, Rickard) graminoids may not be the principle food item in the diet of Microtus pennsylvanicus. In all but five cases grasses composed less than 25 per cent of the stomach contents. Although graminoids appear to be an important factor in the ecology of this vole (Getz), they do not affect it through food habits. The effect may be an indirect one, through associated species which are used as food plants.

Vicia americana was the most preferred food plant, since it was eaten in the greatest quantities, although it was no more abundant than were the other important food plants (see Table 4). Fragaria virginiana was the next preferred species but was far less important than was Vicia.

Hoffman (1958) found a close correlation between breeding activity of Microtus and the amount of vegetative growth. This would indicate a possible relationship between reproduction and nutrition.

This study showed a similar tend. The reproductive rate was highest during June, the month of most active vegetative growth, and declined during July and August as plant growth decreased.

The low ratio of immature voles to adults indicates a very low survival rate for the young voles. Other factors influencing the ratio would be the transferal of animals from the immature to the adult class on maturation and emigration of unestablished young animals from the trapping area. Also, the pooling of trapping results from years of different reproductive levels would influence the ratio.

Bendell (1959) and Hoffman (op. cit.) found that prenatal mortality could be correlated with population changes, but was insufficient to account for the total change. Both authors claimed that the major influence on population changes was postnatal mortality, mainly from birth to one month of age. Bendell decided that food supply determined the survival of young white-footed mice (P. leucopus) in this period.

In this study a similar situation was evident. The number of young voles caught was far lower than the number of placental scars and embryos would indicate. Since there appeared to be very little loss of embryos, the mortality must have occurred at or just after birth.

Survival of young voles appeared to be highest during July and August (See Fig. 6), since the condition of the females examined indicated a similar reproductive level for the whole summer. Early postnatal mortality appeared to be a major factor in controlling vole populations, as found by Hoffman, and by Bendell in Peromyscus.

There appeared to be a considerable variation in survival of young voles from different habitats. The deciduous forest habitat allowed the survival of the greatest proportion of young. Survival of young voles was lower in the grassland habitat. In the other habitats the survival rate of young voles was so low that no immature animals were caught. The differential mortalities of young voles in different habitats could be correlated with the different population levels of voles from these areas.

Microtus pennsylvanicus is characteristically an animal of moist herbaceous vegetation. Although, under conditions of low competition, it may occur in other habitat types, it is mainly found in the dense herbaceous vegetation of the ecotonal region between deciduous forest and grassland. Other

vegetation types apparently do not provide favorable enough environmental conditions to support high vole populations.

Vegetation is an important factor controlling the ecological distribution of Microtus. Although certain aspects of the environment may be more important than the others, the reaction of an animal to the environment is rarely, if ever, dependent on any single factor. The effect of vegetation on the environment of the animal is multiple and complex, and is second in importance only to the major climatic features of the area. The animal will occur in those habitats where the environment provided by the vegetation and climate falls within the ecological tolerance ranges of the available biotypes of the species.

SUMMARY

1. Trapping studies were undertaken during the summers of 1959, 1961, and 1963 in the vicinity of the Alberta Biological Station 20 miles west of Turner Valley, Alberta to survey the food habits and local distribution of mice.

2. Four species of mice were caught in numbers sufficient to indicate habitat preferences. The main requirement of Peromyscus maniculatus appeared to be sparse vegetation with a high proportion of forbs. Microtus pennsylvanicus and Zapus princeps were found mainly in deciduous forest areas, where Zapus appeared to prefer slightly denser and moister habitat than did Microtus. Clethrionomys gapperi was found in areas having a coniferous element of varying proportions.

3. The stomach contents of the four main species were preserved for identification of the plants eaten. Standard measurements were taken on all mice caught. The numbers of embryos, and placental scars as well as resorbed embryos was recorded as a means of indicating reproductive condition.

4. Plants were collected, identified and pressed for herbarium specimens. A reference series of microscope slides of epidermal tissue was prepared from small portions of each specimen.

5. Epidermal tissue fragments from the stomach contents were identified by comparison with the reference slides. This procedure was possible only with the food selected by Microtus, as no provision had been made for the identification of seeds of fruits, which were eaten by the other three mice.

6. Mice were found to be selective in their choice of food materials. Only two plant species were eaten in large quantities by Microtus. Vicia americana was eaten by 87 per cent of the mice, and Fragaria virginiana was eaten by 53 per cent of the mice. Sixty-three of 73 mice ate four or fewer plants.

7. Adults and immature females fed on a greater range of plant species than did immature males. The low figure for immature males may have been due to the low sample size. Animals in all age and sex categories ate an average of about three plant species per mouse. No seasonal variation was found in food habits. Availability of the major food plants appeared to control their proportions in the diet.

8. The reproductive activity of the females was highest during June. Almost no prenatal loss was observed. Since the trapping results showed a far lower proportion of immature mice than would be expected from the observed reproductive condition of the females, the mortality of the young must have occurred from birth to the weaning stage.

9. Cover was the primary factor observed in influencing vole populations. The effect of distribution and abundance of the major food plants was apparent only in those areas where the cover values were similar. There, greater abundances of food plants supported higher populations of voles.

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APPENDIX A

Vegetation analysis

The vegetation of each area was listed by species and a notation of abundance was made according to the scale of Tansley and Adamson (1913, from Phillips 1959), as follows;

va (8) - very abundant

a (7) - abundant

vc (6) - very common

c (5) - common

f (4) - frequent

o (3) - occasional

r (2) - rare

vr (1) - very rare

The scale was modified by adding the 'very common' and 'common' categories. Also included in the scale was the prefix 'l' to denote localized conditions.

The numbers in brackets indicate the numerical values given the categories to calculate index of abundance When the prefix 'l' was used the numerical value of the category dropped to the next lower value.

APPENDIX A

Vegetation analysis

Plant species	Area 1	2	3	4	5	6	7	8	9
Achillea millefolium	c	o	c	f	c	c	f	vc	f
Actaea rubra									
Agoseris glauca	f	vr	r	vr		o	r	o	r
Agropyron sp.		o							
A. dasystachyum	c		c						
A. griffithsi	r								
A. inerme	vr								
A. latiglume	r								
A. smithii	o								
A. subsecundum	c		r	o	f		c	f	o
A. trachycaulum	c	o	f			o	o	o	c
Agrostis sp.			o	o		c			f
A. scabra	f								
Allium cernuum	f					o		r	f
Alopecurus sp.		vr							
Amelanchier alnifolia					r			r	vr
Anemone multifida	o		o				o	o	
Antennaria sp.			1f						
Apocynum sp.									r
A. androsaemifolium	1vc				1f				
Arctostaphylos uva-ursi							1vc		1c
Arnica amplexicaulus		o							
Artemisia sp.				f					
A. frigida	c						1o	o	
A. ludoviciana	c				1f		f		
Aster sp.	f	o	c	o	c		f	f	1va
A. laevis									
Astragalus sp.	o		1vc				f		
Beckmannia syzigachne		r							
Betula sp.			1c						
Bromus sp.		vr							vr
B. ciliatus	c		o		r	a	o		r
B. inermis	va								
B. pumpellianus	c			1c	o	o	o	f	o
Calamagrostis sp.		vr	1o	r					
C. montanensis	o					1c			va
Campanula rotundifolia	c		vr	o	r	f	f	r	c
Carex sp.	a	1c	1c	1f		c			c
Castilleja mineata					vr		r		
Collomia linearis	r			r				r	
Danthonia intermedia			o	o	va	r	o		

Plant species	Area								
	1	2	3	4	5	6	7	8	9
Danthonia parryi	lf		o						
Delphinium bicolor	o								
D. glaucum	o					vc	r	o	c
Deschampsia caespitosa	f	c	c			r			
Descurainia richardsonii						f			
Dodecatheon conjugens	c					c			f
Eleagnus argentea							vc		
Elymus innovatus	f			lf		va	vc	a	c
Epilobium angustifolium	o			c	r	lva	o	o	va
E. hornemannii		r	lo						
Equisetum sp.									r
Erigeron sp	f			r		r			vc
Festuca brachyphylla							o		
F. idahoensis	c								
F. saximontana			f						
F. scabrella	f		o	a	c	f	f		c
Fragaria virginiana	vc	f	c	c		va	c	va	lvc
Gaillardia aristata	o		r	r	vr		r	r	r
Galium boreale	c		vc		lo	f	f	r	f
Gentiana sp.	o								
Gentianella amarella		lo			r				
Geranium sp.		lo							
G. richardsonii	o			r	r	r	r	o	o
G. viscosissimum	o			f					
Geum triflorum	f		o	f					
Glyceria grandis		lvc							
G. striata			lc						
Hackelia floribunda	r					vr			
Haplopappus lyalli									r
Hedysarum alpinum		lvc		r		o	o	o	r
Helictotrichon hookeri	f			o		lvc	r		
Heracleum lanatum	lc			vr		f		r	lva
Heuchera sp.					c				
Hierchloe odorata	vc					o			
Hordeum jubatum		r							
H. vulgare		r							
Juncus sp.						r			
J. balticus	o								
Juniperus sp.							o		
Koeleria cristata	o		f	o			o	o	o
Lappula echinata		r		r					
Lathyrus ochroleucus	o		r		o	a	r	f	vc
Lilium philadelphicum								r	r
Linum lewisii	c								
Lithospermum ruderale	o			o				o	r
Lomatium dissectum								o	r

Plant species	Area 1	2	3	4	5	6	7	8	9
Mentha arvensis				1f					
Mertensia paniculata	1f					1c			1c
Monarda fistulosa								o	1c
Muhlengergia sp.	1c								
Orthocarpus luteus							o		
Oxytropis sp.				vr					
O. campestris	o				f	r			r
O. splendens	o								
Ozmorhiza depauperata									o
Parnassia fimbriata			1c						
Pedicularis sp.	r								
Petasites sp.		1f							
Phalaris arundinacea	1c								
Phleum pratense	vc	a	vc	o	o	1c	1c	1o	f
Picea glauca		vr		1o	r	o	o	r	1o
Pinus contorta			1c		r		r	1o	
Plantago sp.				r				o	
P. major		f	r						
Poa sp.	c	c	o	o	f	vc	f	o	c
Polygonum amphibium		1o							
Populus balsamifera						r	o		1a
P. tremuloides	r			1o	f	vc	o	c	a
Potentilla sp.	f					o			o
P. effusa		r		f					
P. fruiticosa	o	vr	f	f		r	f	vc	o
P. gracilis	vc	f	c	vc	o	f	r	f	c
P. pennsylvanica			f				r		
Prunus virginiana var. melanocarpa	o								
Pyrola sp.							o		
Rhinanthus crista-galli						r			
Ribes sp.									r
R. oxyacanthoides				vr		r	o	vr	
Rosa sp.	f			vr	1c	r	vc	vc	f
Rubus sp.			vr			r			
Rumex sp.	o	vr				f			r
Salix sp.		vr	1c			o	o	o	
Senecio sp.				vr		r	f		o
Shepherdia canadensis							vc		
Sisyrinchium montanum				vr					
Smilacina stellata					1f	1f	c	f	o
Solidago sp.				1c					
S. gigantea	1va				vr			1vc	1vc
S. missouriensis			f				o		
Sparganium chlorocarpum		vr							
Stachys palustris	o								f
Stipa columbiana	1c			o	c	r	f	f	a
S. richardsonii	1c				va	r			
Symphoricarpos occidentalis	f				1c		o	1c	

Plant Species	Area 1	2	3	4	5	6	7	8	9
Taraxacum officinale		r	vc	o	f	vc	f	lf	lvc
Thalictrum sp.	vc	vr	c		r	c		lf	lvc
Thlaspi arvense	o			r		r		r	
Tragopogon dubius	r								
Trifolium hybridum		lvc							
Trisetum cernuum				vr	a				
Urtica gracilis		vr						vr	r
Valeriana septentrionalis							vc		
Veronica sp.			lo						
Vicia americana	o	f	o	o	o	va	c	o	
Viola rugulosa									lvc
Zizia aptera	o	r	r			r	r		r
Zygadenus elegans						r			

Plant species	Area									
	10	11	12	13	14	15	16	17	18	19
Achillea millefolium	c	c	f	c	o	r	f		r	c
Actaea rubra				o						
Adoxa moschatellina										1f
Agoseris glauca	vr	r		o		vr				r
Agropyron subsecundum	r	1f		r		vr				
A. trachycaulum	f			o		r	o	f	c	o
Agrostis sp.						f	f			c
Allium cernuum			r							
Alnus crispa					1c	r				
Amelanchier alnifolia			f						c	
Anemone multifida		o	o		o		r	o		
Antennaria sp.		1c				1o	o			
Apocynum androsaemifolium	1c								1va	
Arctostaphylos uva-ursi		1a			c	f	vc			o
Artemisia sp.									a	
A. ludoviciana		o			o					
Aster sp.	c	c	f	c	o	c	c		1c	vc
Astragalus sp.						vr		o		
Bessya cinerea								f		
Betula sp.										1c
Bromus ciliatus	o	1r			1f				o	
B. pumpellianus	f	1o			r	r	o			
Calamagrostis sp.			f	1va	1o				r	
C. montanensis	1vc	1c			f	a	o			o
Campanula rotundifolia		f				o	o		o	
Carex sp.	f	1c	c	1c	1f	o				va
Castilleja mineata					r	o				
Cerastium arvense				f			o			
Cirsium sp.							r			
Clematis verticellaris		o					r			
Collomia linearis	vr									
Cornus canadensis					1f	r	c			o
Cruciferae				r			o			
Danthonia intermedia	o					1f	r			r
Delphinium glaucum	o		o	r		1r				
Deschampsia caespitosa	r		r	o		r				f
Dodecatheon conjugens		f	f						f	
Eleagnus argentea									a	
Elymus innovatus	va	a	o	o	vc	a	vc			o
Epilobium angustifolium	a		c		c	vc	1c		1c	c
E. hornemannii										o
Equisetum sp.		o		vc						
Ericaceae						1vc				
Erigeron sp.						o				
Festuca idahoensis							f			

Plant species	Area									
	10	11	12	13	14	15	16	17	18	19
Festuca saximontana		c		o	c		c			
F. scabrella			o							
Fragaria virginiana	vc	c	a	vc	vc		vc			f
Gaillardia aristata			o							
Galium boreale	f	f	c	o	o	r	o		o	o
Gentiana sp.						vr				
Gentianella amarella	f	f		r	o		lo			r
Geranium richardsonii			r		vr			f		
G. viscosissimum	c	o		o						
Glyceria grandis				lf						lc
G. striata	vr			o						
Habenaria bracteata										r
Hackelia floribunda	lf									
Happlopappus lyalli			o							
Hedysarum alpinum				r	f			vr		
Helictotrichon hookeri						o				
Heracleum lanatum	vc									
Hieracium sp.		r								
Hierchloe odorata							o			
Hordeum jubatum							lf			
Juncus balticus										lvc
Juniperus sp.			r		r	vr	o	r		
Koeleria cristata						vr				
Lathyrus ochroleucus	c	o	c	o		vc	c		lc	
Linnaea borealis						f				
Linum lewisii		vr								
Lithospermum ruderale		o								
Lomatium dissectum		o								
Lonicera involucrata					r				r	
Lupinus sp.		lf								
Luzula sp.					r					
Mertensia paniculata		lc		c	o	o				
Mitella nuda				lvc						
Monarda fistulosa										c
Moneses uniflora						lo				
Oxytropis sp.							r	o		
O. campestris		o			f		r			
Ozmorhiza depauperata		o		o						
Parnassia sp.										f
P. fimbriata				o						
Pedicularis bracteosa					r					
P. groenlandica										o
Petasites sp.				o						f
Phacelia heterophylla								vr	vr	
Phleum pratense	o	o	o	f	o	vr	o			c
Picea glauca	o	r	r	o	o	o	c			r
Pinus contorta	r	r			c	vc	c	o		c
Plantago sp.							r		r	

Plant species	Area									
	10	11	12	13	14	15	16	17	18	19
P. major	r		f							
Poa sp.	o	c	f	f	c		c	f	1f	
Polygonum viviparum										r
Populus balsamifera	1c	o		r	f		1o			
P. tremuloides	c	c	vc	o	c	1va	1o			f
Potentilla fruiticosa		o	o	r	1o	vr	r	c	r	
P. gracilis	r	f	f	o	o	vr	o		o	o
P. pennsylvanica	r	r			r					f
Prunus virginiana		o							1va	
Pyrola sp.		o			r		o			
Rhinanthus crista-galli			o							
Ribes sp.		r					o			r
R. oxyacanthoides				r		vr			r	
Rosa sp.	c	vc	o	f	a	r	f		1c	f
Rubus sp.	r	o	f			r	o		f	1o
Rumex sp.	r									o
Salix sp.		vr		r	c		o		r	o
Senecio sp.	o	r			o	r				
Shepherdia canadensis		o		vc	r	r				
Smilacina stellata	f	1f		f	r					
Solidago sp.	r	r				r			f	
S. missouriensis				r			r			r
Spiranthes romanzoffiana					vr					
Spirea lucida		c			vc	1o	o			
Stipa columbiana	o		o	o						
Symphoricarpos occidentalis			f		c		o		c	
Taraxacum officinale	vc	vc	c	f		o	f	vr		1c
Thalictrum sp.	c	c	f	c						
Tragopogon dubius									r	
Trifolium hybridum			o			1f	1va			
Trisetum cernuum	vc					f				r
T. spicatum					f		f			
Urtica gracilis									1f	
Vaccinium sp.		1vc			1o		o			o
Valeriana septentrionalis						r				
Vicia americana	1a	f	c	o	o	f	o			vc
Viola sp.	r						r			
V. adunca		f								
V. nuttallii									o	
V. rugulosa		f								
Zizia aptera			o							
Zygadenus elegans						r				

Appendix B Common names of plant species included in the report, according to Moss (1959).

Abies lasiocarpa	alpine fir
Achillea millefolium	common yarrow
Actaea rubra	red banberry
Adoxa moschatellina	moschatel
Agoseris glauca	false dandelion
Agropyron dasystachyum	northern wheat grass
A. griffithsi	
A. inerme	
A. latiglume	
A. smithii	western wheatgrass
A. subsecundum	bearded wheatgrass
A. trachycaulum	slender wheatgrass
Agrostis scabra	hairgrass, ticklegrass
Allium cernuum	nodding onion
Alnus crispa	green alder
Alopecurus aequalis	water foxtail
Amelanchier alnifolia	saskatoon berry
Anemone multifida	cut-leaved anemone
Antennaria sp.	pussytoes, everlasting
Apocynum androsaemifolium	spreading dogbane
Arctostaphylos uva-ursi	common bearberry, kinnikinnik
Artemisia frigida	pasture sagewort
A. ludoviciana	prairie sagewort
Aster ciliolatus	Lindley's aster
A. laevis	smooth aster
Astragalus sp.	milk vetch
Arnica amplexicaulus	
Beckmannia syzigachne	slough grass
Besseya cinerea	kitten-tails
Betula sp.	birch
Bromus ciliatus	fringed brome
B. inermis	awnless brome
B. pumpellianus	northern awnless brome
Calamagrostis montanensis	plains reed grass
Campanula rotundifolia	bluebell, harebell
Carex sp.	sedge
Castilleja mineata	common red paint brush
Cerastium arvense	mouse-ear chickweed
Cirsium sp.	thistle
Clematis verticellaris	purple clematis
Collomia linearis	collomia
Cornus canadensis	bunchberry
Danthonia intermedia	timber oat grass
D. parryi	Parry oat grass
Delphinium bicolor	low larkspur
D. glaucum	tall larkspur
Deschampsia caespitosa	tufted hair grass
Descurainia richardsonii	grey tansy mustard

Appendix B

Dodecatheon conjugens	shooting star
Eleagnus argentea	silverberry, wolfwillow
Elymus innovatus	hairy wild rye
Epilobium angustifolium	fireweed
E. hornemannii	
Equisetum sp.	horsetail
Erigeron compositus	fleabane
Festuca brachyphylla	
F. idahoensis	bluebunch fescue
F. scabrella	rough fescue
F. saximontana	
Fragaria virginiana	wild strawberry
Gaillardia aristata	gaillardia
Galium boreale	northern bedstraw
Gentiana sp.	gentian
Gentianella amarella	felwort
Geranium richardsonii	
G. viscosissimum	sticky purple geranium
Geum triflorum	old man's whiskers, prairie smoke
Glyceria grandis	
G. striata	fowl manna grass
Habenaria viridis	bracted orchid
Hackelia floribunda	stickseed
Happlopappus lyalli	
Hedysarum alpinum	
Helictotrichon hookeri	Hooker's oat grass
Heracleum lanatum	cow parsnip
Heuchera cylindrica	alumroot
Hieracium sp.	hawkweed
Hierchloe odorata	sweetgrass
Hordeum jubatum	foxtail barley
H. vulgare	barley
Juncus balticus	wire rush
Juniperus sp.	juniper
Koeleria cristata	June grass
Lappula echinata	bluebur
Larix sp.	larch
Lathyrus ochroleucus	vetchling
Lilium philadelphicum	western wood lily
Linnaea borealis	twinflower
Linum lewisii	wild blue flax
Lithospermum ruderale	puccoon
Lomatium dissectum	prairie parsley
Lonicera involucrata	bracted honeysuckle
Lupinus sp.	lupine
Luzula sp.	wood rush

Appendix B

Mentha arvensis	wild mint
Mertensia paniculata	tall mertensia
Mitella nuda	bishop's cap, mitrewort
Monarda fistulosa	wild bergamot, horsemint
Moneses uniflora	one-flowered wintergreen
Muhlenbergia richardsonis	mat muhly
Orthocarpus luteus	owl-clover
Oxytropis campestris	late yellow loco weed
Ozmorhiza depauperata	sweet cicely
Parnassia fimbriata	grass-of-Parnassius
Pedicularis bracteosa	lousewort
P. groenlandica	elephant's head
Petasites sp.	sweet colt's foot
Phacelia heterophylla	scorpion weed
Phalaris arundinacea	reed canary grass
Phleum pratense	timothy
Picea glauca	white spruce
Pinus contorta	lodgepole pine
P. flexilis	limber pine
Plantago major	common plantain
Poa pratensis	Kentucky blue grass
Polygonum amphibium	water smartweed
P. viviparum	bistort
Populus balsamifera	balsam poplar
P. tremuloides	aspen
Potentilla effusa	
P. fruticosa	shrubby cinquefoil
P. gracilis	gracefull cinquefoil
P. pennsylvanica	Pennsylvania cinquefoil
Prunus virginiana	chokecherry
Pseudotsuga menziesii	Douglas fir
Pyrola sp.	wintergreen
Rhinanthus crista-galli	yellow rattle
Ribes oxyacanthoides	wild gooseberry
Rosa arkansana	prairie rose
R. woodsii	common wild rose
Rubus strigosus	wild red raspberry
Rumex occidentalis	western dock
Salix sp.	willow
Senecio sp.	groundsel, ragwort
Shepherdia canadensis	Canadian buffalo-berry
Sisyrinchium montanum	blue-eyed grass
Smilacina stellata	star-flowered Solomon's seal
Solidago missouriensis	
S. gigantea	goldenrod
Sparganium chlorocarpum	bur-reed
Spiranthes romanzoffiana	ladies tresses
Spirea lucida	white meadowsweet
Stipa columbiana	columbia needlegrass
S. richardsonii	Richardson's needlegrass

Appendix B

Symphoricarpos occidentalis . . .	buckbrush
Taraxacum officinale	common dandelion
Thalictrum venulosum	meadow rue
Thlaspi arvense	pennycress, stinkweed
Tragopogon dubius	goatsbeard
Trisetum cernuum	nodding trisetum
T. spicatum	spike trisetum
Urtica gracilis	common nettle
Vaccinium sp.	blueberry
Valeriana septentrionalis	valerian
Veronica sp.	speedwell
Vicia americana	wild vetch
Viola adunca	early blue violet
V. nuttallii	yellow prairie violet
V. rugulosa	western Canada violet
Zizia aptera	meadow parsnip
Zygadenus elegans	white camas

Appendix C. Stomach Analysis.

Plant Species*	Percent Composition of Mouse Stomachs Mouse Number														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
V. americana				>75	>50	>75	75	>50	50		25	25	75		50
F. virginiana												25	>10	>75	<25
T. officinale	10						10								
A. millefolium	10	10									<25				<25
L. ochroleucus		20	10												
Grass				10	>25	>10	10	25	25	>75	<50	<25	<10		<25
Insect material		10						10	10		10	<25			
Fungus								<10	<10		5	<25			
Poa sp.		5													
Aster sp.	<10														
M. paniculata															
B. inermis	50	5	25												
E. angustifolium															
F. idahoensis			5												
Muhlenbergia sp.		5	25												
B. ciliatus			25												
A. multifida															
O. campestris		5													
P. pratense															
A. subsecundum															
A. trachycaulum															
A. cernuum															
Astragalus sp.		5													
Carex sp.					5										
C. linearis															
D. parryi	<10														
Delphinium sp.	<10														
D. caespitosa			10												
G. aristata															
G. boreale															
J. balticus		5													
R. crista-galli	<10														
Rosa sp.															
Rumex sp.	<10														
S. gigantea															
S. columbiana															
Thalictrum sp.															
Z. aptera															
Algae															5
Starch cells															

* See Appendix B. for full names of plant species

Appendix C.

Plant species	Percent composition of mouse stomachs														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
V. Americana	75		25	75	50	50	50	50	25	50	25	75	50	50	50
F. virginiana	10				25	10	25	25	25	25	25	25	25	25	25
T. officinale		10	10				10					10			
A. millefolium					10				25	10					
L. ochroleucus							10							10	
Grass	10		10			10			10				10		
Insect material			25			10			10						
Fungus															
Poa sp.											10				
Aster sp.							10				10				
M. paniculata				5											
B. inermis															
E. angustifolium															
F. idahoensis											10				5
Muhlenbergia sp.															
B. ciliatus															
A. multifida				25							10				
O. campestris															
P. pratense															
A. subsecundum															
A. trachycaulum		75													
A. cernuum															
Astragalus sp.															
Carex sp.															
C. linearis															
D. parryi															
Delphinium sp.															
D. caespitosa															
G. aristata															
G. boreale								10							
J. balticus															
R. crista-galli															
Rosa sp.															5
Rumex sp.															
S. gigantea															
S. columbiana															
Thalictrum sp.															
Z. aptera															
Algae															
Starch cells															

Appendix C.

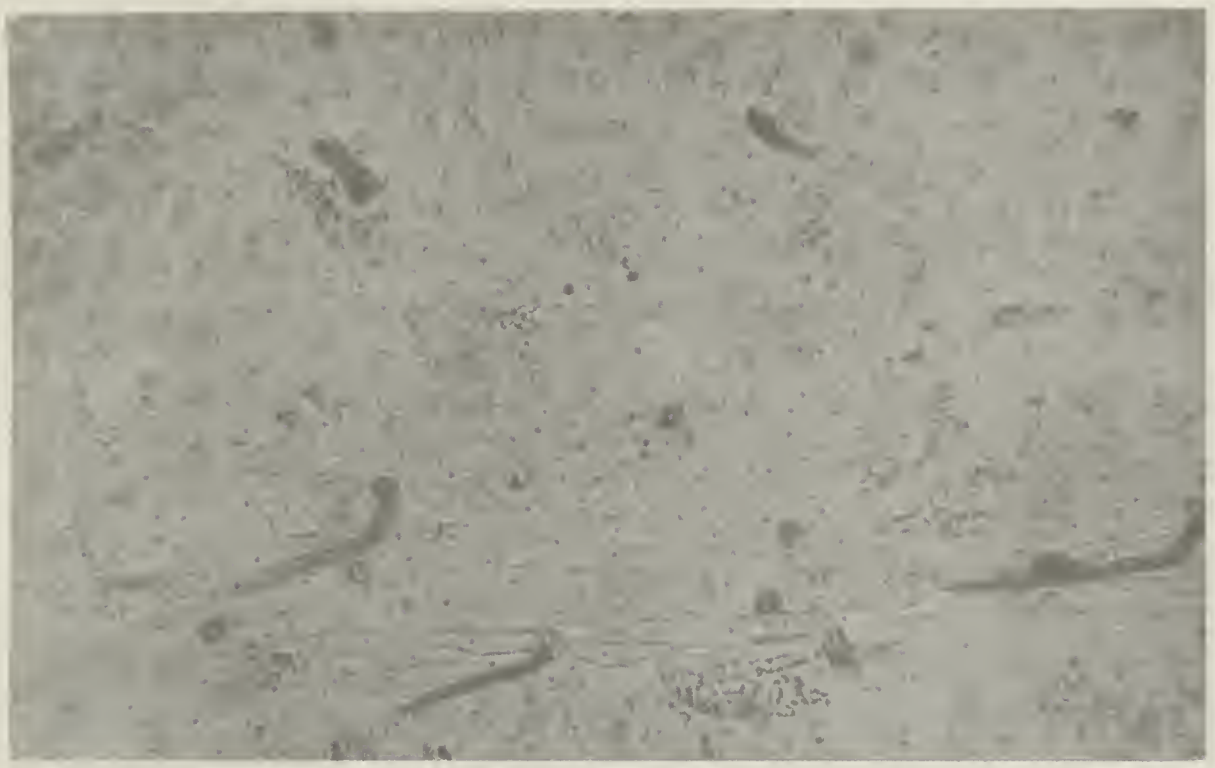
Plant Species	Percent composition of mouse stomachs														
	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
V. americana	50	50	>75	25	<75	>50	>50	<50	>50	>75	>50	50	75	>75	>75
F. virginiana	<25	>25		>10	<25		>25	>10		5	>25		<25		<10
T. officinale	10			<50				5					5		
A. millefolium			10									<25			
L. ochroleucus								>10							
Grass	<25	5					>10	5		5					
Insect material										5					
Fungus												5			
Poa sp.				5					>25			<25			
Aster sp.		10													
M. paniculata			5					5							
B. inermis											5				
E. angustifolium															
F. idahoensis															
Muhlenbergia sp.											5				
B. ciliatus															
A. multifida															
O. campestris															
P. pratense															
A. subsecundum															
A. trachycaulum															
A. cernuum					5										
Astragalus sp.															
Carex sp.															
C. linearis															
D. parryi															
Delphinium sp.															
D. caespitosa															
G. aristata															
G. boreale															
J. balticus															
R. crista-galli															
Rosa sp.															
Rumex sp.															
S. gigantea															
S. columbiana							>25								
Thalictrum sp.									5						
Z. aptera															
Algae															
Starch cells															

Appendix C.

Plant Species	Percent composition of mouse stomachs														
	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
V. americana	75	10	10	75	50	25	75	75	25	50	75	50	25	75	
F. virginiana		50				25		10		25	25				
T. officinale		10			25	25			50	25			10		75
A. millefolium		10		10									10		
L. ochroleucus			75												
Grass					10		10					10	10	10	
Insect material		10													
Fungus			10		5	10									
Poa sp.				10											10
Aster sp.		25													
M. paniculata															
B. inermis															
E. angustifolium	10														
F. idahoensis															
Muhlenbergia sp.															
B. ciliatus															
A. multifida															
O. campestris															
P. pratense															
A. subsecundum															
A. trachycaulum															
A. cernuum															
Astragalus sp.															
Carex sp.															
C. linearis															
D. parryi															
Delphinium sp.															
D. caespitosa															
G. aristata												25			
G. boreale															
J. balticus															
R. crista-galli															
Rosa sp.															
Rumex sp.															
S. gigantea															
S. columbiana															
Thalictrum sp.															
Z. aptera															
Algae															
Starch cells	5			5									10		

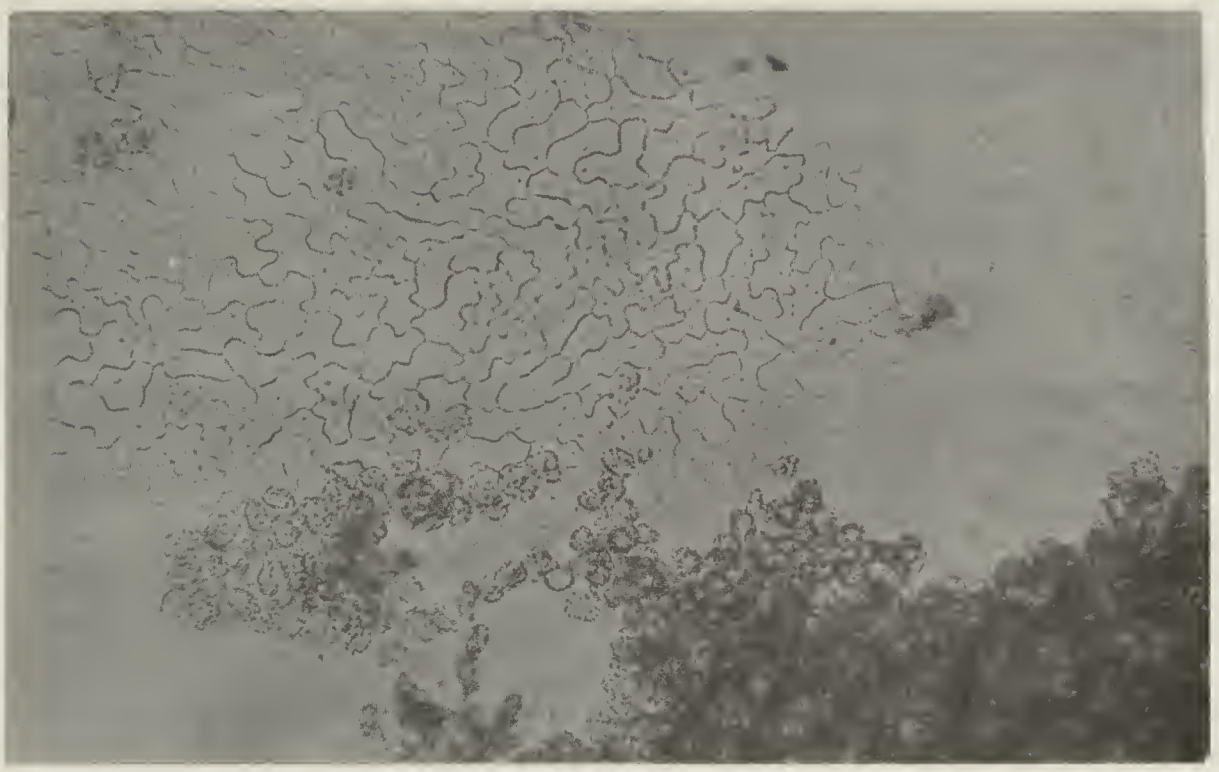
Appendix C.

Plant species	Percent composition of mouse stomachs												
	61	62	63	64	65	66	67	68	69	70	71	72	73
V. americana	25	>50	75	>50	>50	>50	50		>50	>50	75	>50	>50
F. virginiana	25	>25		<25	<25	>25				>25		10	>25
T. officinale	5			<25				<75	25			25	
A. millefolium	25			<10		5							
L. ochroleucus													
Grass					5	5	5	<25	5		<25	5	
Insect material													
Fungus					5	5							
Poa. sp.		<10											
Aster sp.													
M. paniculata													
B. inermis													
E. angustifolium													
F. idahoensis													
Muhlenbergia sp.													
B. ciliatus								<25					
A. multifida													
O. campestris													
P. pratense													
A. subsecundum													
A. trachycaulum													
A. cernuum													
Astragalus sp.													
Carex sp.									<25				
C. linearis													
D. parryi													
Delphinium sp.													
D. caespitosa													
C. aristata													
G. boreale													
J. balticus													
R. crista-galli													
Rosa sp.								<25					
Rumex sp.													
S. gigantea													
S. columbiana													
Thalictrum sp.													
Z. aptera									25				
Algae													
Starch cells													

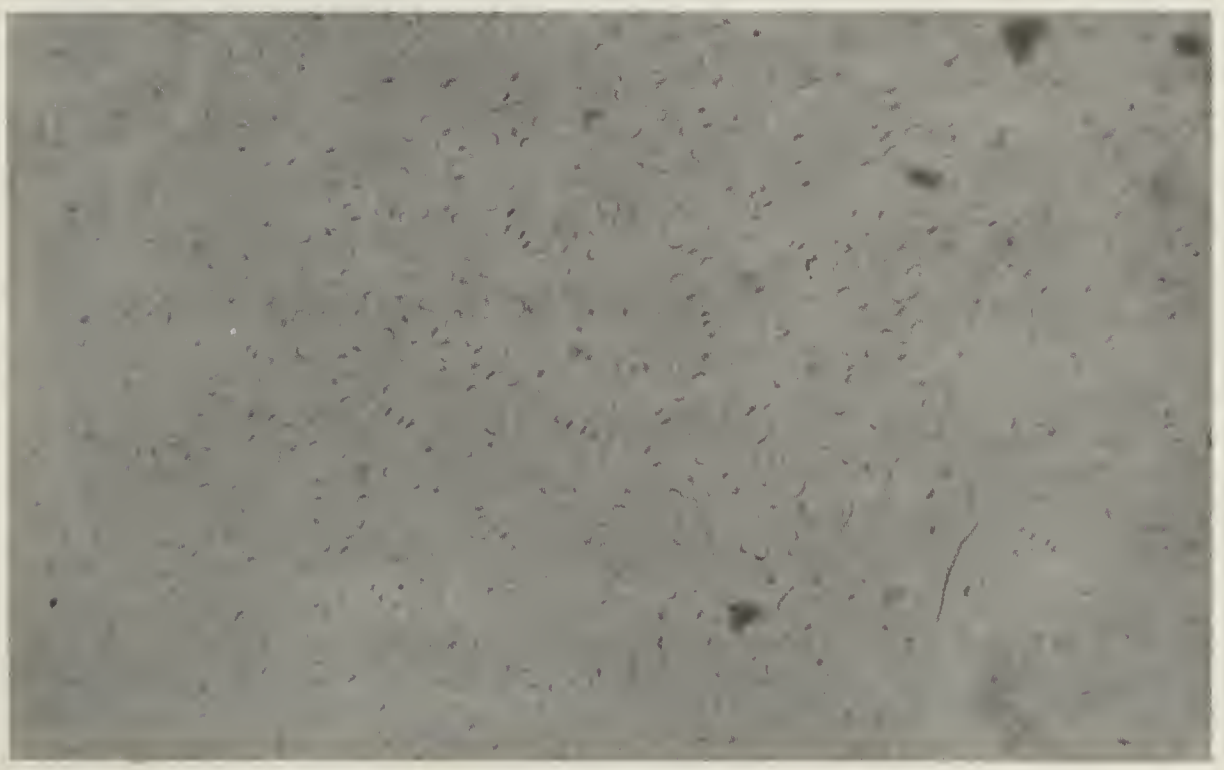


Vicia americana

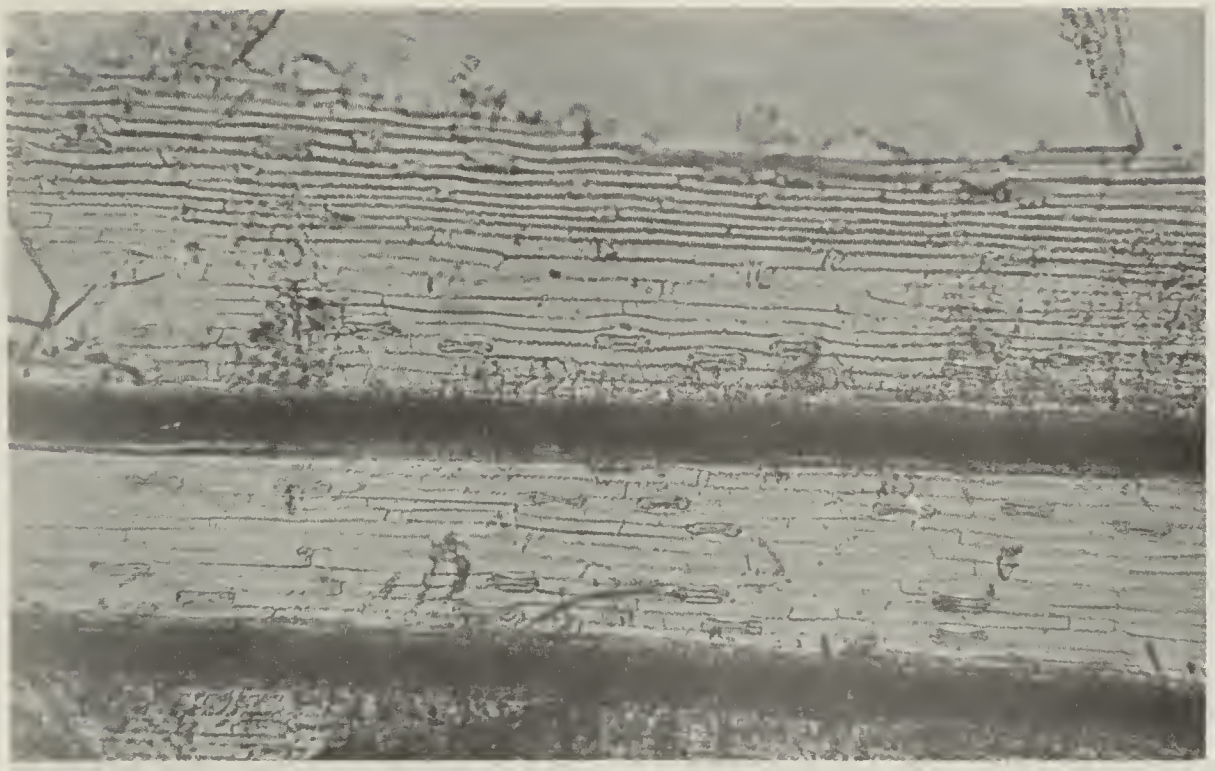
Fragaria virginiana



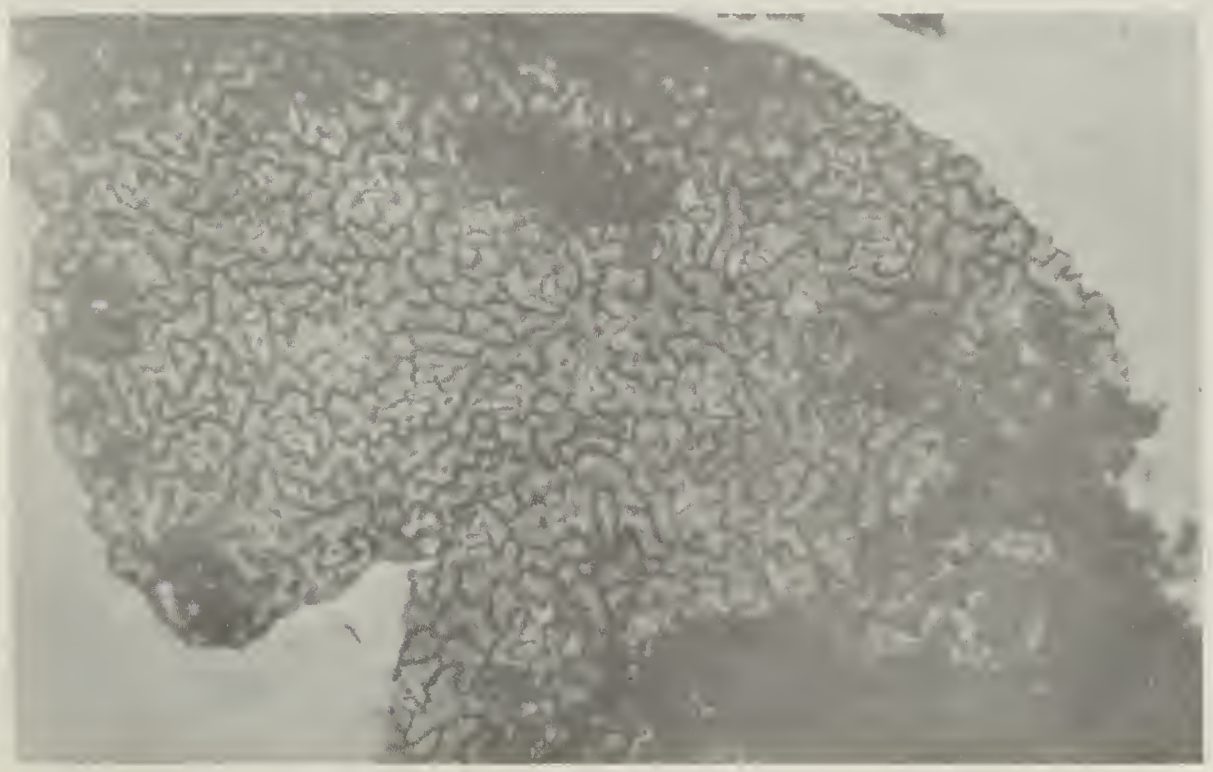
Taraxacum officinale



Lathyrus ochroleucus



Poa interior



Aster laevis

Mertensia paniculata

Bromus inermis